



## The importance of acoustic data from fishing vessels for the analysis and management of the Chilean Jack Mackerel fishery in the South Pacific Ocean

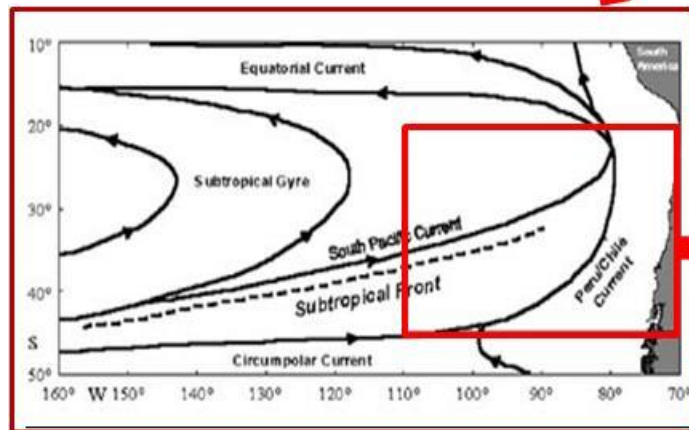
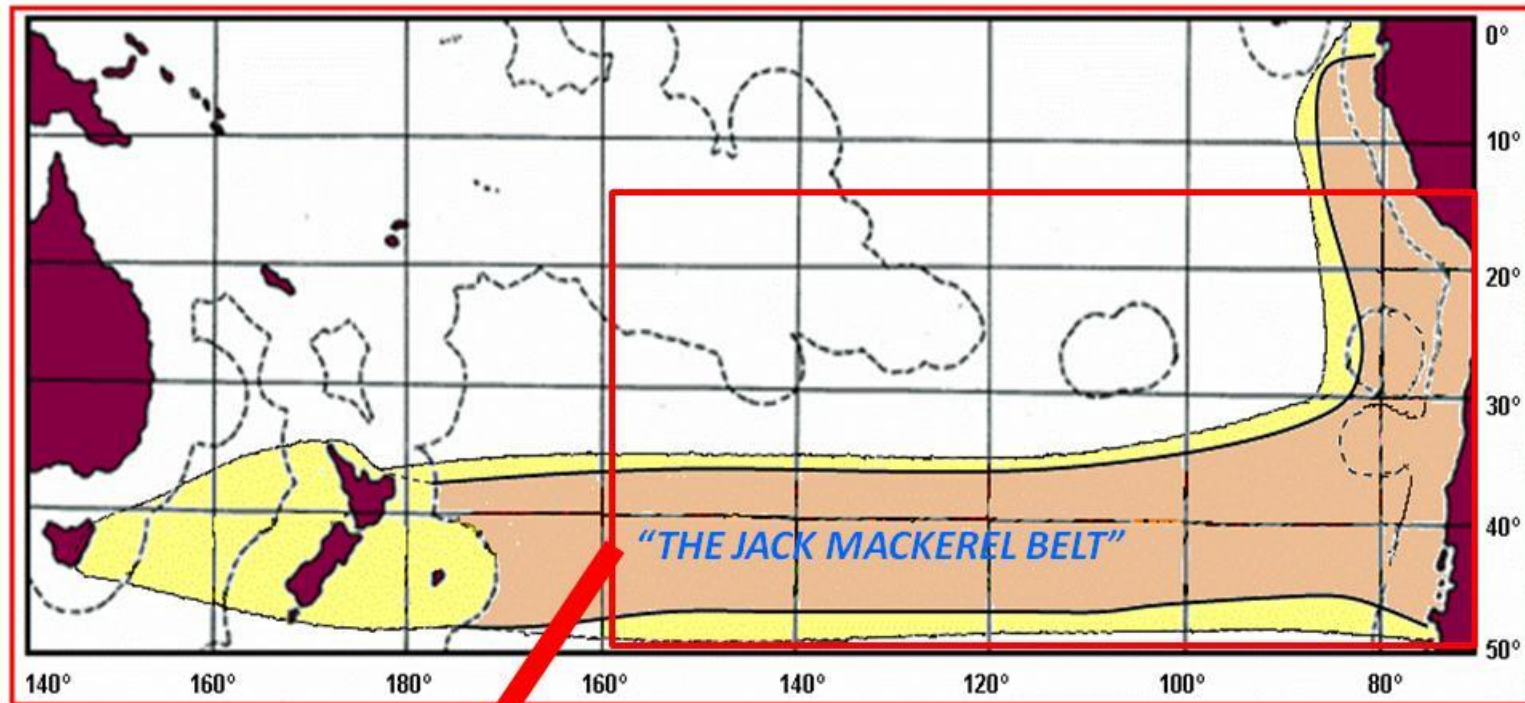
François Gerlotto<sup>1</sup>, Mariano Gutierrez<sup>2</sup>, Jorge Castillo<sup>3</sup>

*1 IRD, UMR Eme (212), Institut de Recherches pour le Développement, Centre de Recherche Halieutique méditerranéenne et tropicale, Sète, France*

*2 UNFV (Universidad Nacional Federico Villarreal), Lima, Peru*

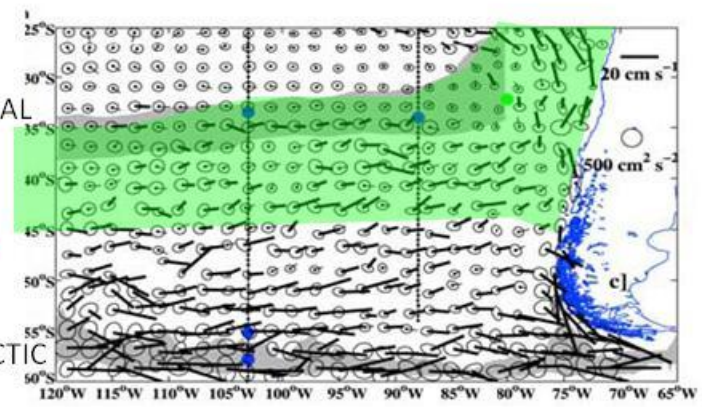
*3 IFOP, Instituto de Fomento Pesquero, Valparaíso, Chile*

# The “jack mackerel belt” (Elizarov et al., 1992; Grechina, 1998).



SUB-TROPICAL  
FRONT

SUB-ANTARCTIC  
FRONT



(from Chaigneau & Pizarro, 2005)





## The fisheries

The acoustic data from research vessels

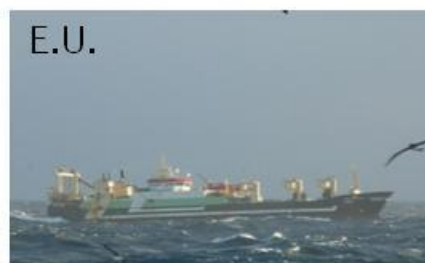
Questions about population structures

Acoustic data from the fisheries

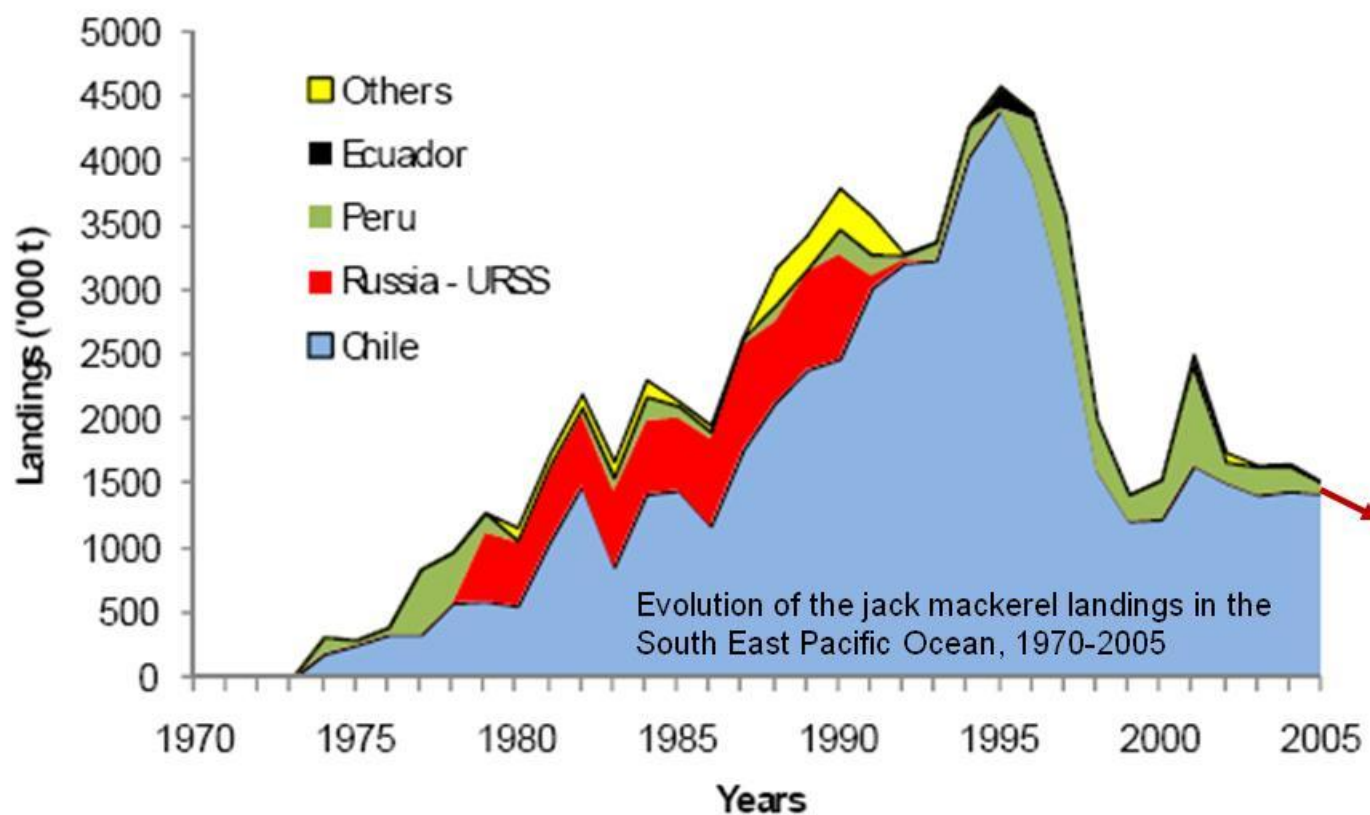
Proposals to SPRFMO



# The fisheries



The major jack mackerel fishing fleets in the Southern Pacific Ocean

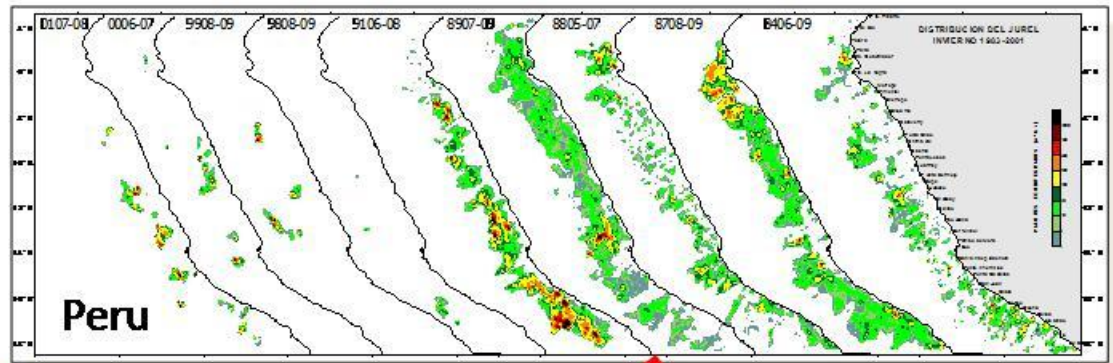
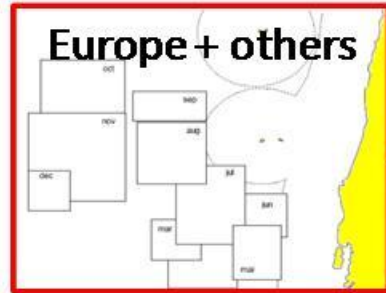


Around 250  
fishing vessels

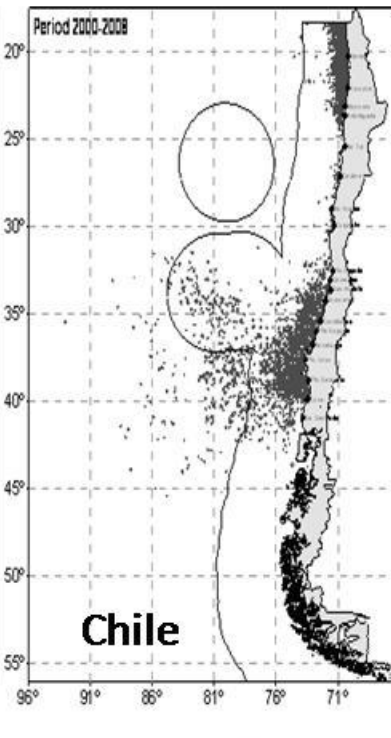
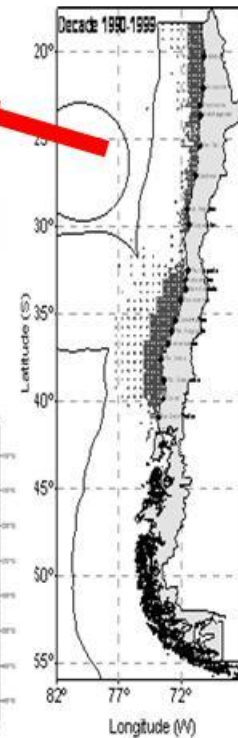
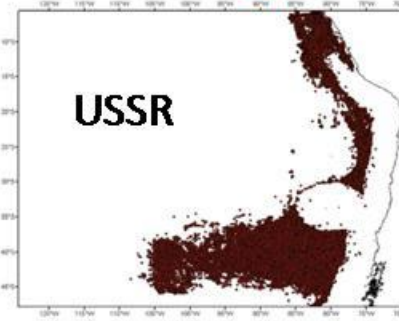
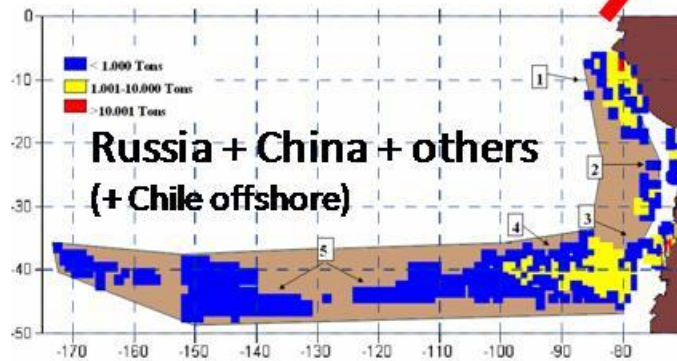
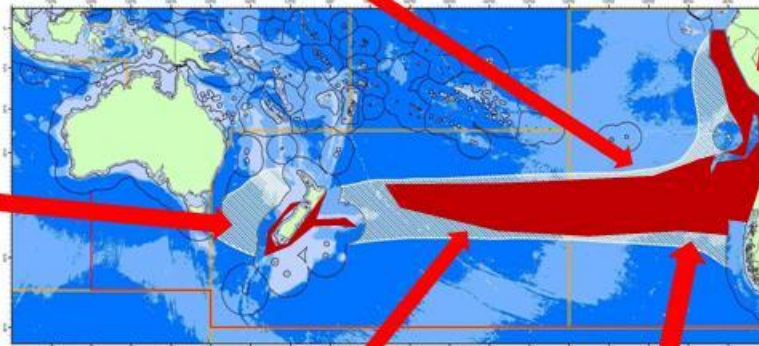
| Country    | Nb of F/V |
|------------|-----------|
| Chile:     | 138       |
| Peru:      | 73        |
| EU:        | 7         |
| Russia:    | 5         |
| China:     | 11        |
| Korea:     | 3         |
| Cuba:      | 4 to 18   |
| NZ:        | 43 (0)    |
| Belize:    | 10        |
| Cook Isl.: | 4         |
| Vanuatu:   | 4         |



# The fishing areas



**New Zealand**





The fisheries

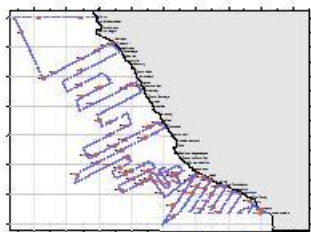
**The acoustic data from research vessels**

Questions about population structures

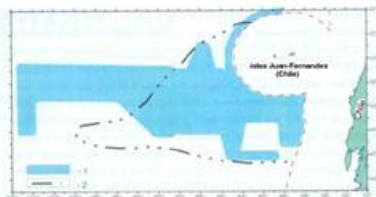
Acoustic data from the fisheries

Proposals to SPRFMO





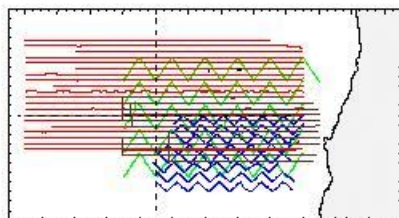
**Acoustic  
sampling  
Peru**



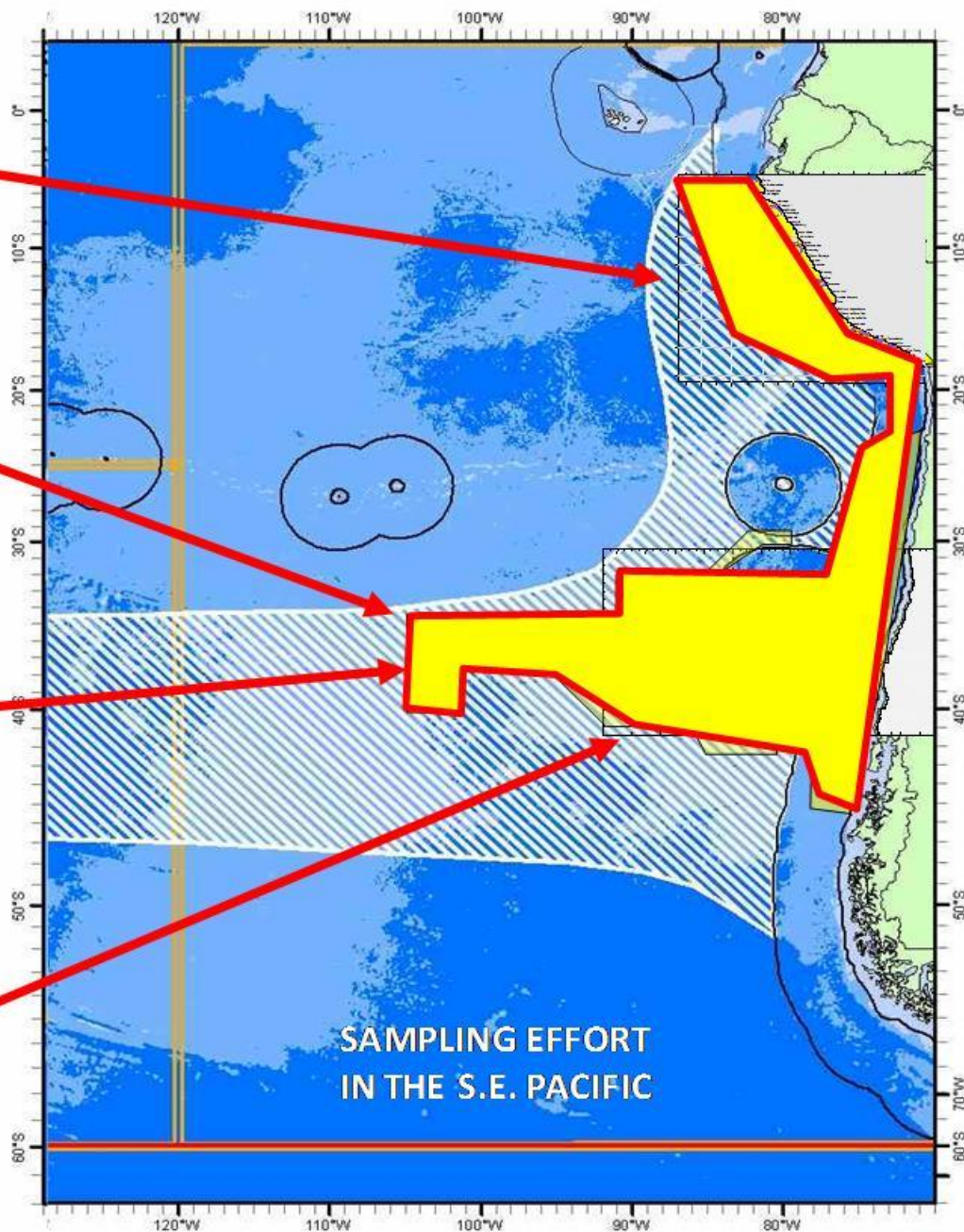
**Acoustic  
sampling  
International**

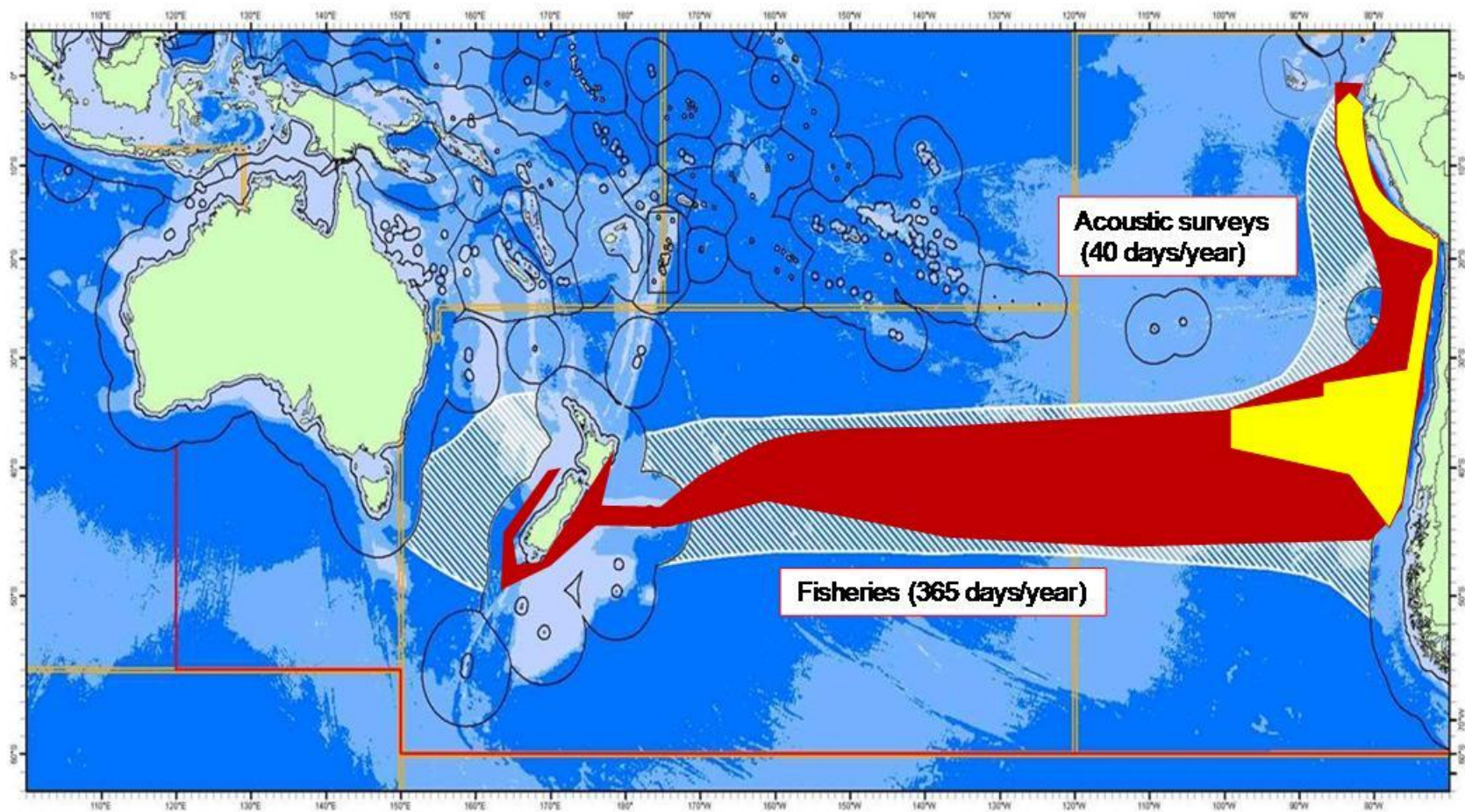
Fig. 3. Sector estudiado por el B.I.C. "Atahualpa" en octubre 2002 - enero 2003 (1) y operaciones de la flota pesquera en octubre - enero de los años 1979-1992 (2).

**Global coverage of  
scientific surveys**



**Acoustic  
sampling  
Chile**





**If (approx. 50%?) of the biomass is evaluated yearly, less than 5 % of the time/space distribution of CJM is monitored by acoustic surveys.**





The fisheries

The acoustic data from research vessels

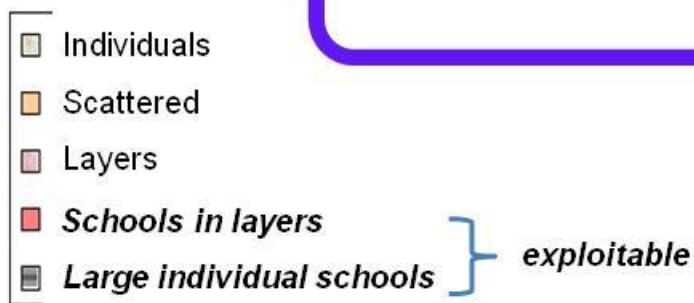
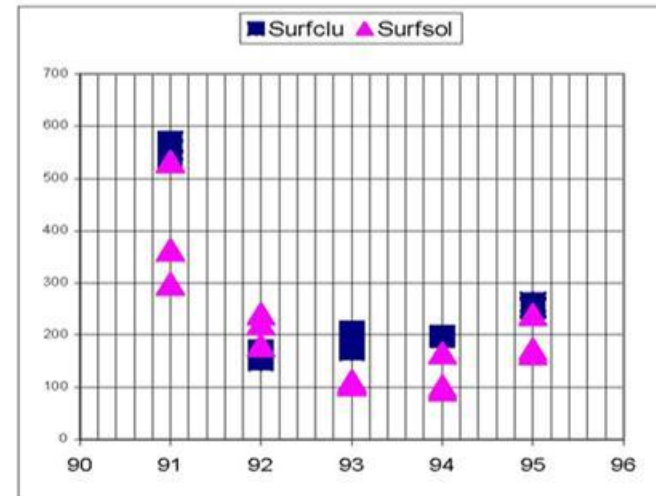
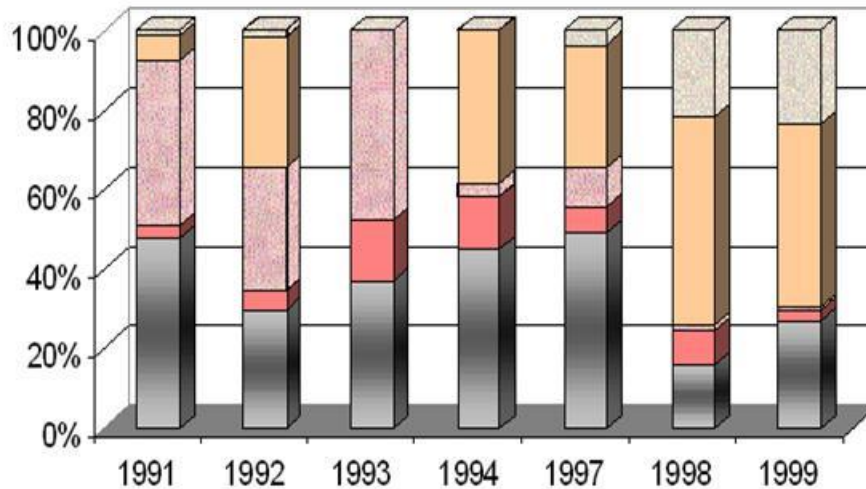
**Questions about population structures**

Acoustic data from the fisheries

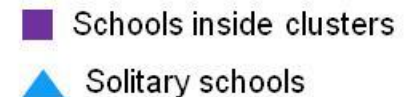
Proposals to SPRFMO



# I. High variability of aggregation patterns (Chile, 1991–1999)



ENSO events

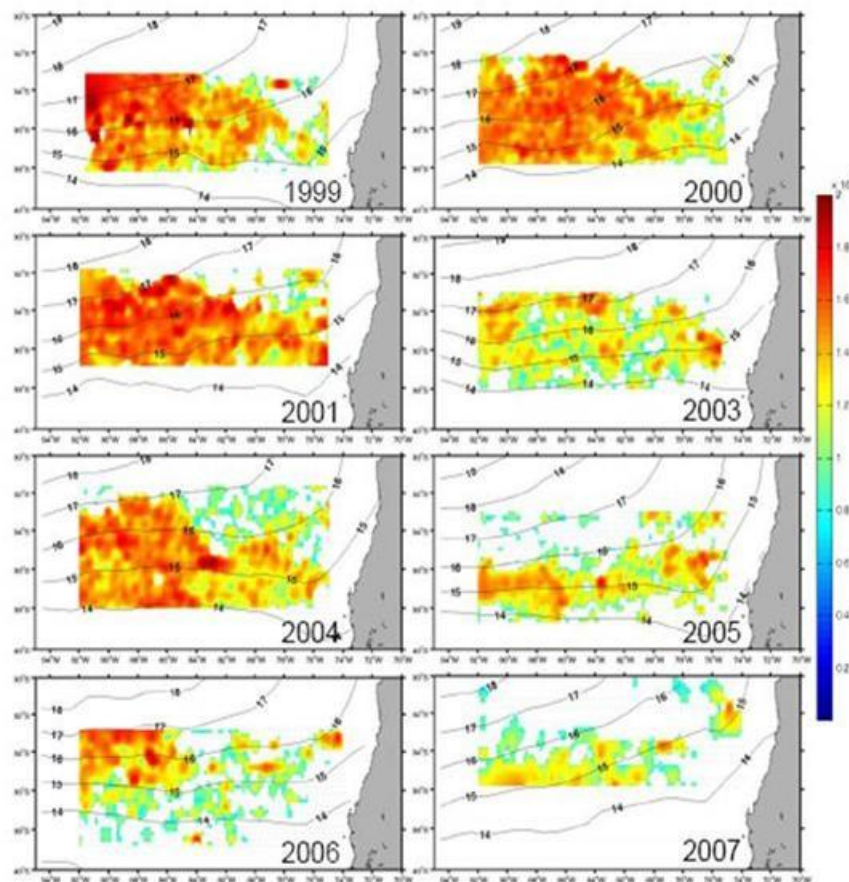


Variability in proportions of aggregation type (left) and individual school surface (right) in relation with the El Niño Southern Oscillation (ENSO)

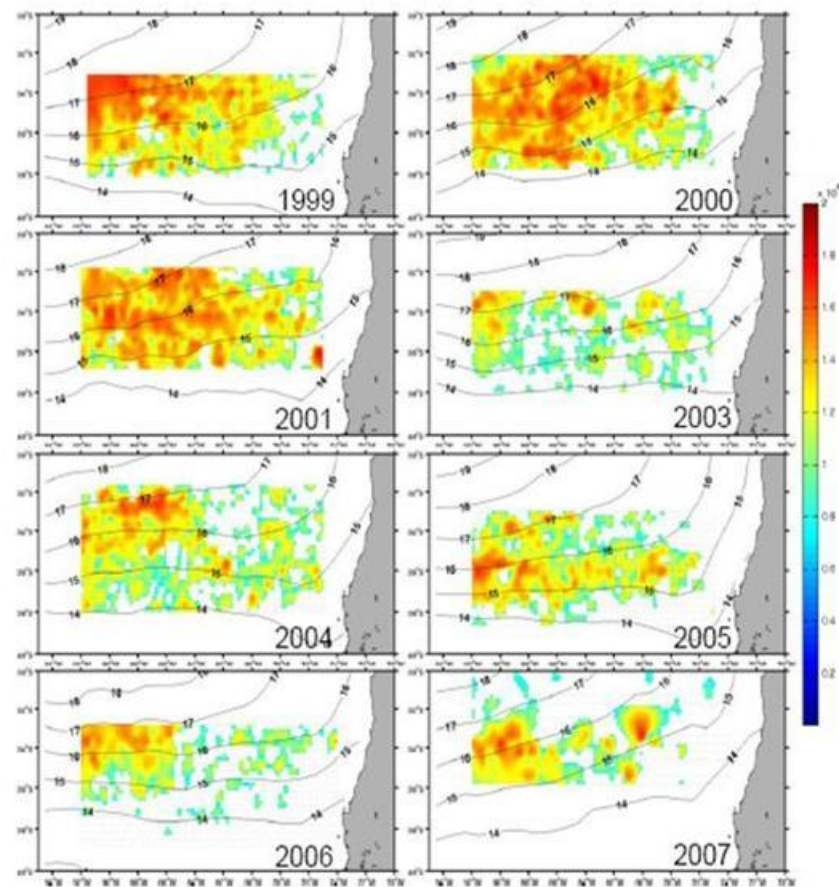


## II. Changes in spawning behaviour, 1999–2007 (jack mackerel, Chile)

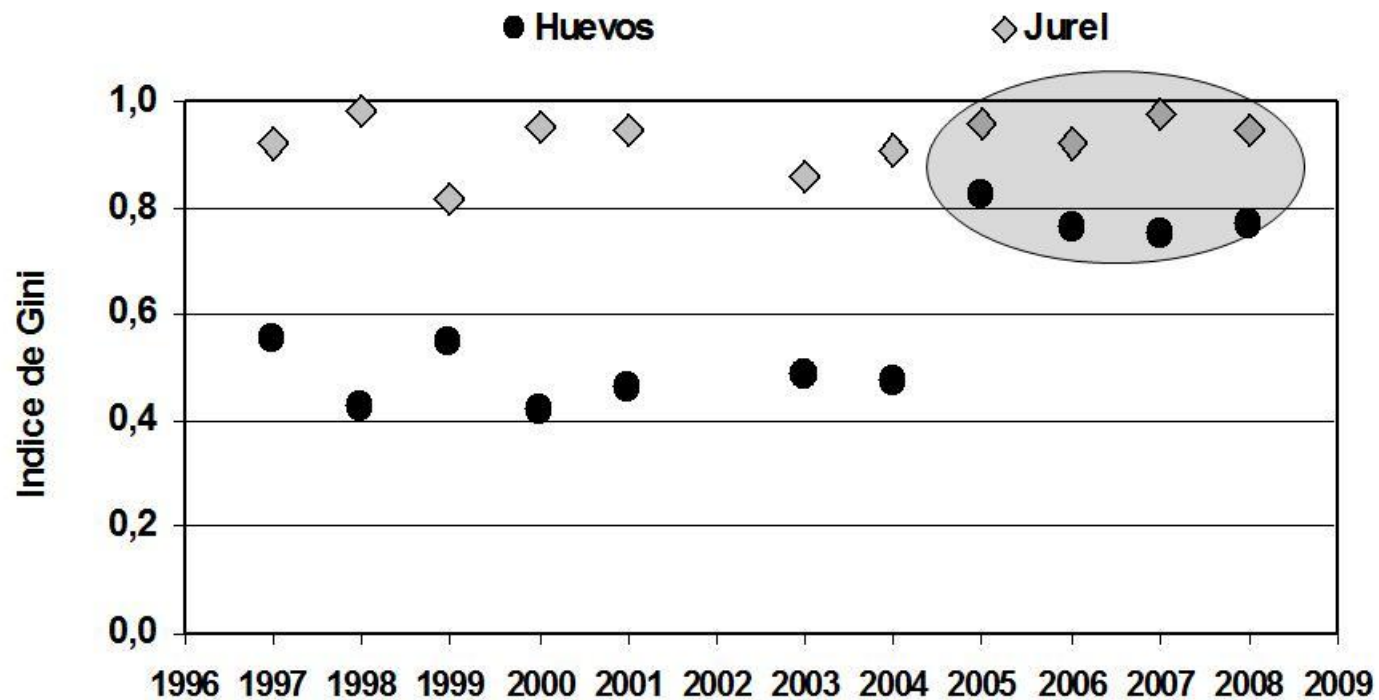
Eggs



Larvae

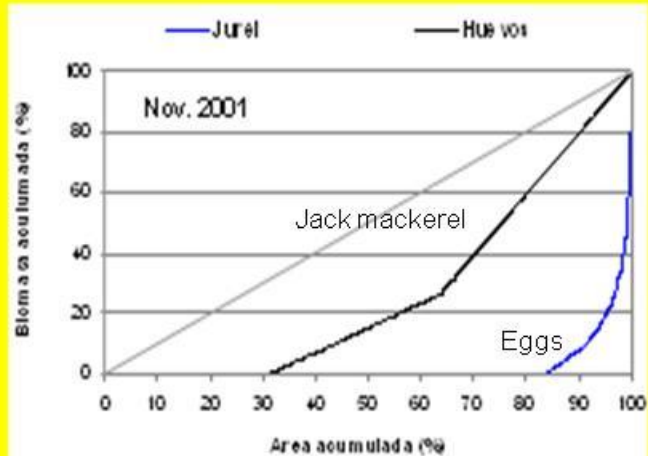
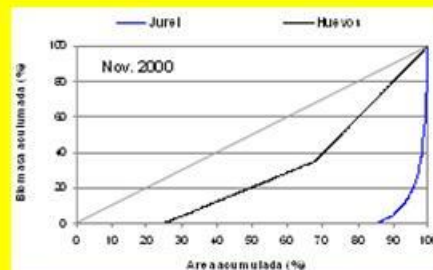
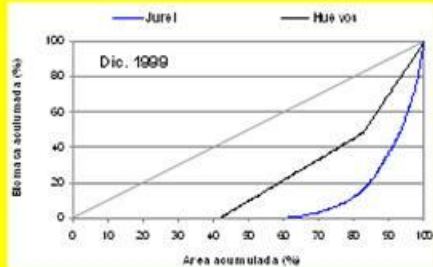
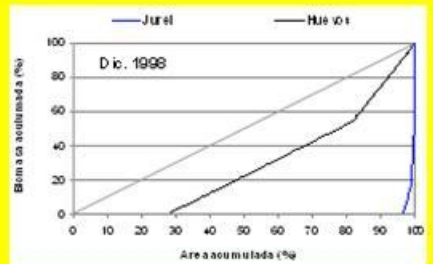
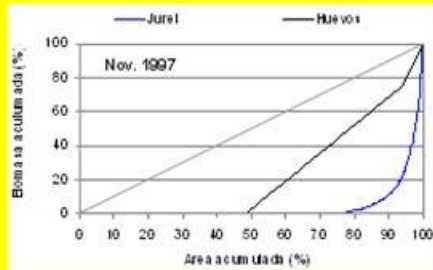


### III. Changes in aggregation behaviour, 1997–2008 (jack mackerel, Chile)



Gini Index of eggs changed in 2005 from 0.4 - 0.6 to 0.8 - 1 showing a higher degree of aggregation

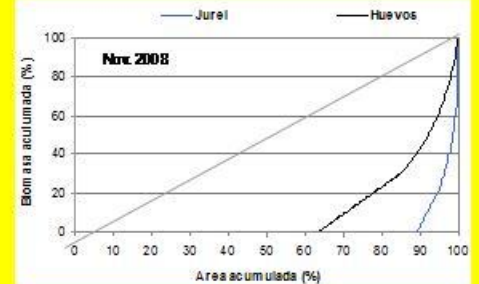
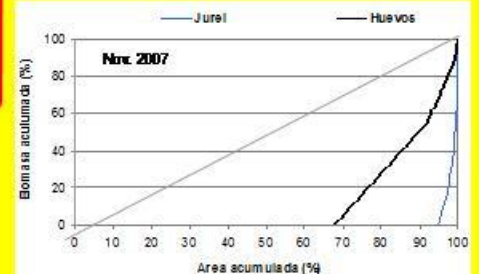
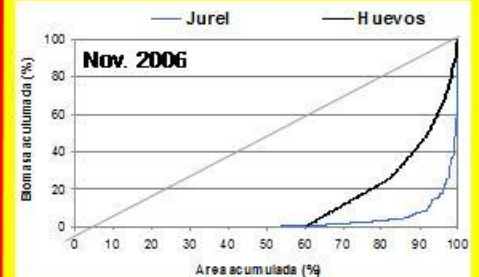
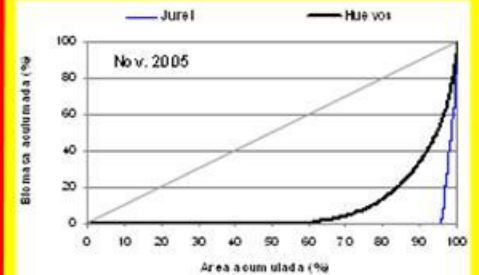
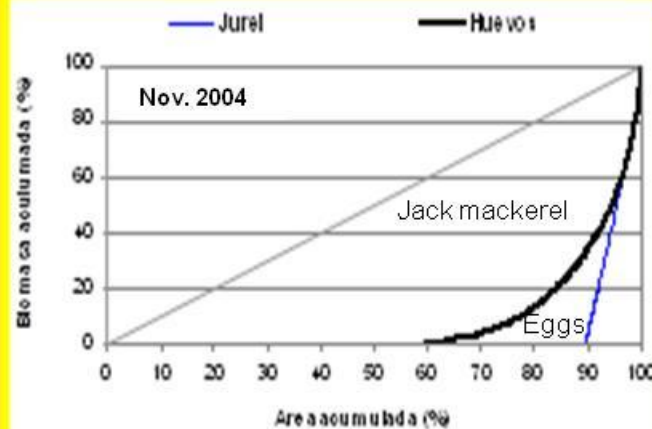
## IV. Lorenz curves for CJM fish and eggs, Chile, 1997 – 2008



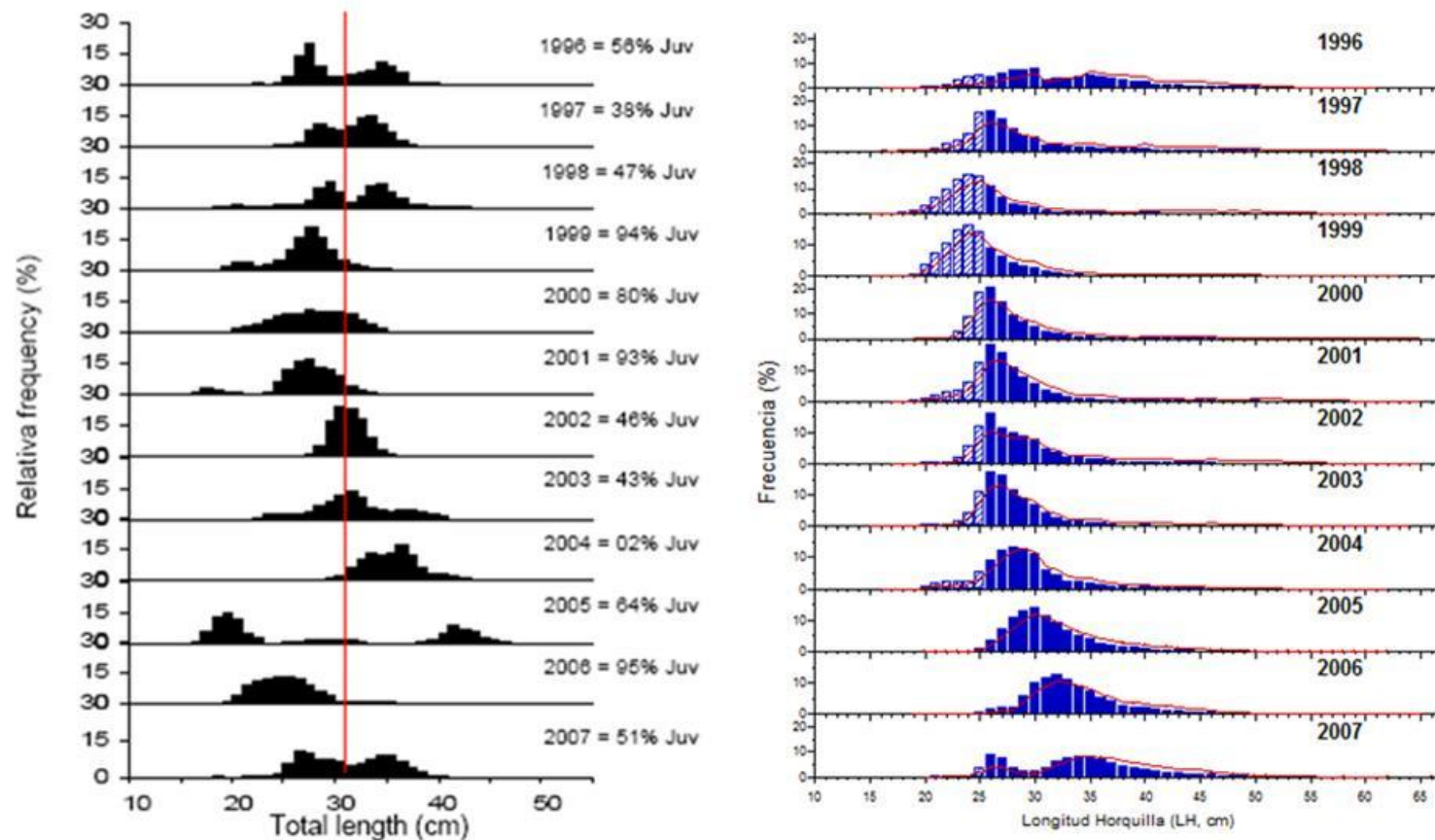
**Two families of curves:**

Before 2004: low gregarism

Since 2004: high gregarism



## V. Differences in demographic structures 1997 – 2008



Length structure of catches in Peru (left)  
and Centre-South Chile (right)  
period 1996-2007



The fisheries

The acoustic data from research vessels

Questions about population structures

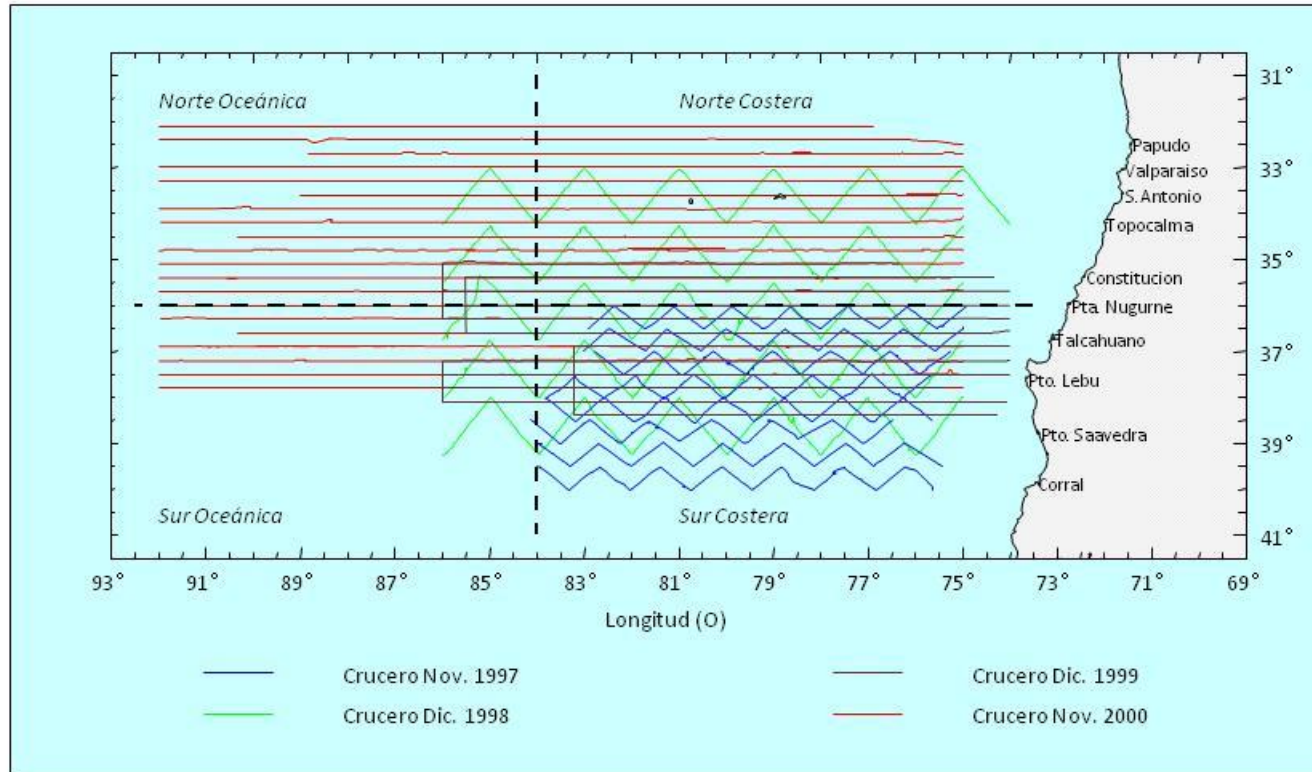
**Acoustic data from the fisheries**

Proposals to SPRFMO



# I. Fishing ships managed by the scientists (hired)

Example: Data collected simultaneously by several fishing vessels, following a sampling strategy decided by the scientists



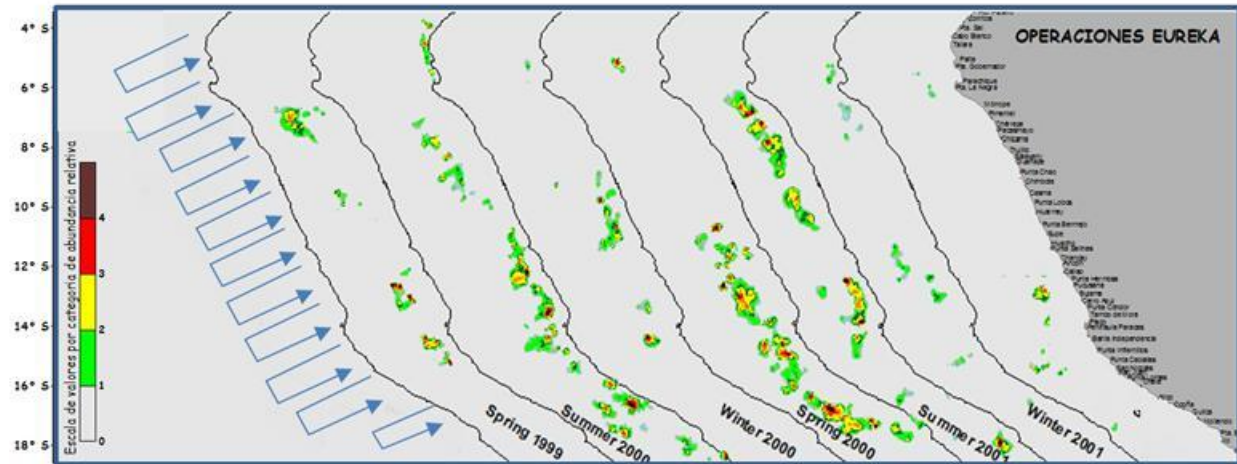
Rastrillo surveys  
in  
Nov. 1997,  
Dec. 1998,  
Dec. 1999,  
Nov. 2000

Rastrillo strategies in Chile. Different examples of surveys from 1997 to 2000 using 5 to 10 ships with parallel tracks in the spawning zone



# I. Fishing ships managed by the scientists (hired)

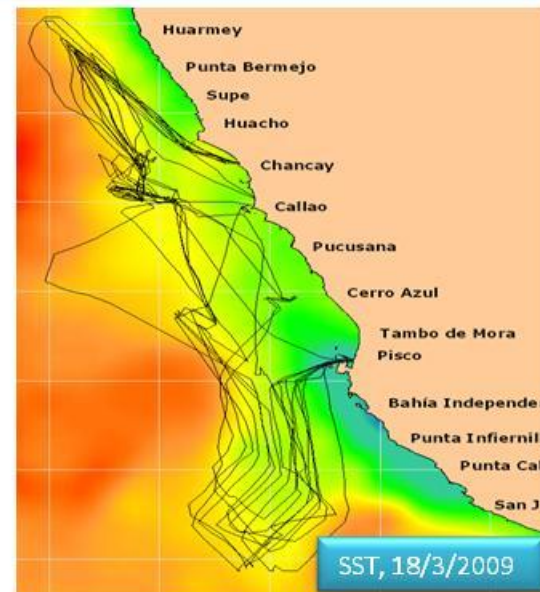
Example: Data collected simultaneously by several fishing vessels, following a sampling strategy decided by the scientists



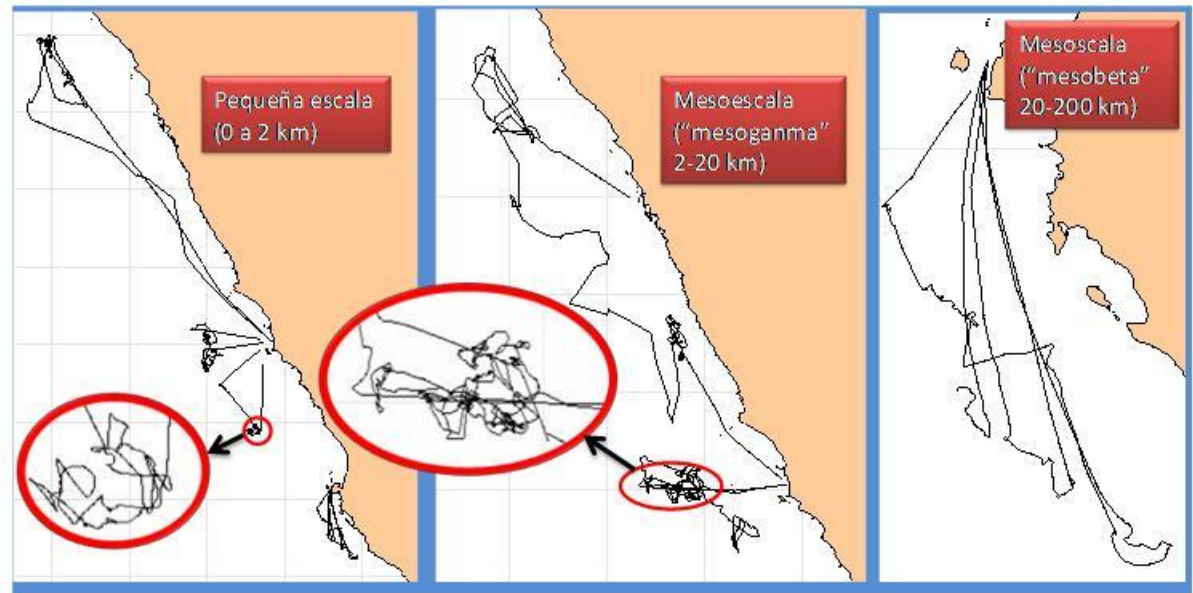
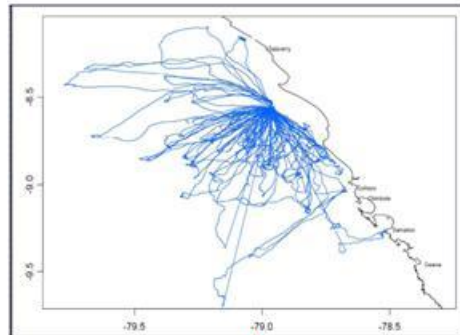
EUREKA strategies in Peru.

Above: standard strategy using several ships leaving simultaneously various harbors along the coastline.

Below: local EUREKA in the fishing grounds using 10 ships from 2 companies (TASA: 8; AUSTRAL: 2)  
The sea surface temperature (SST) is indicated



## II. Routes made by free fishing vessels: the “predator” survey



Seabirds



Fishers

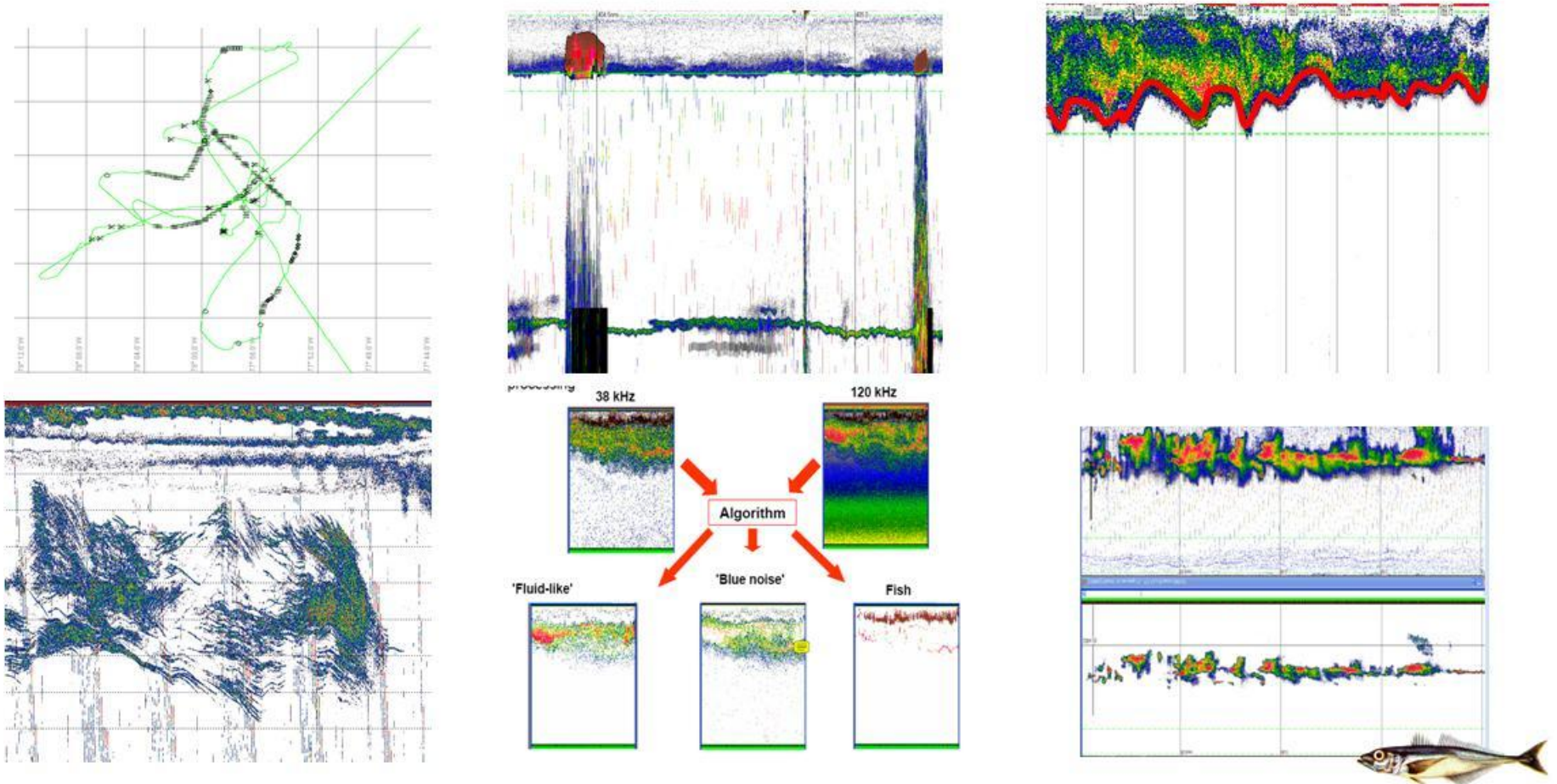
$$P(l_j) \sim l_j^{-\mu}$$

(Lévy fly)



### III. Acoustic information available from fishing vessels during survey and fishing operations

- Time-spatial location of fishery resources and an indication of “skippers behaviour”
- Time-spatial distribution of preys (krill, zooplankton, mesopelagic fish, all micronekton)
- Continuous measurement of ecosystem indexes: thermocline, oxycline, internal waves, biovolume, fish & prey abundance etc.
- Detection of top predators.
- Multifrequency species identification on vessels equipped with 2 frequencies.
- Possibility of automated acoustic processing aboard fishing vessels.



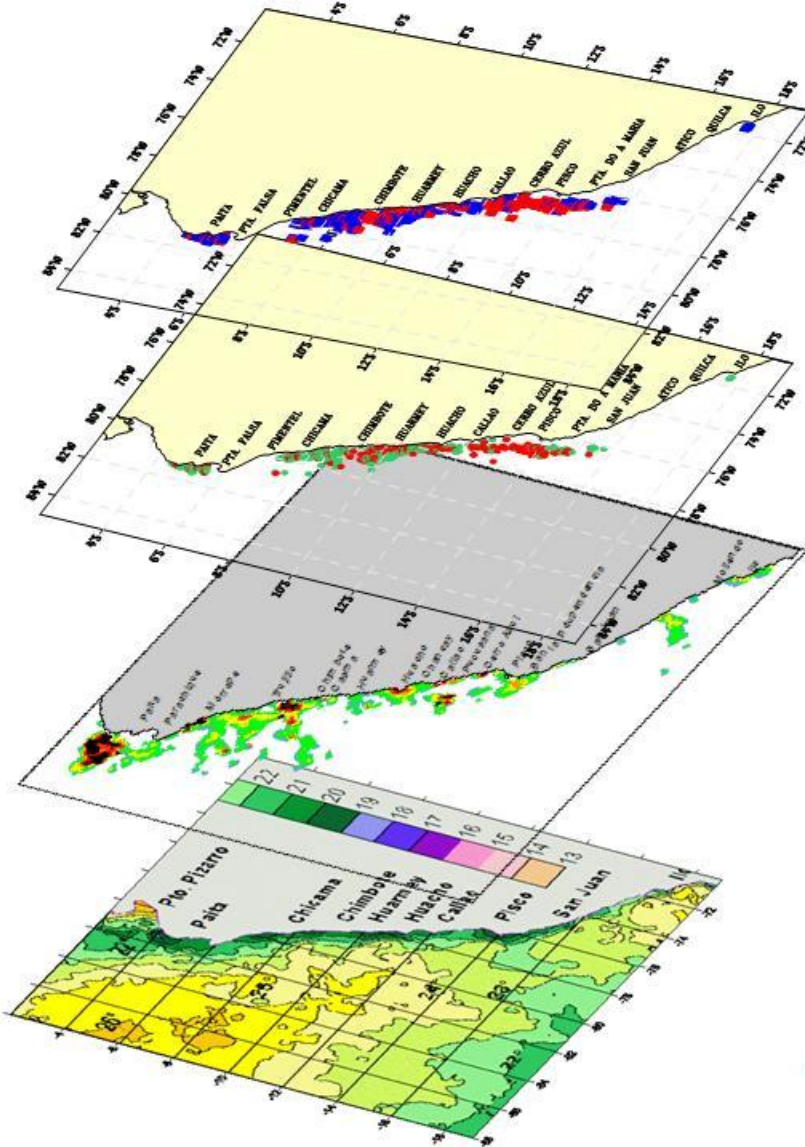
## IMARPE-TASA, case of Peru

## Datos acústicos de los barcos pesqueros

Bitácoras  
observadores  
a bordo

Cruceros  
Evaluación  
Acústica  
(BIC y barco  
de monitoreo)

# Oceanografía



## INDUSTRIA

# IMARPE

- ◀ Evaluación cpue/densidad
- ◀ Ecología
- ◀ Comportamiento micro-escala
- ◀ Evaluación global biomasa y área de distribución
- ◀ Definición área de prospección





The fisheries

The acoustic data from research vessels

Questions about population structures

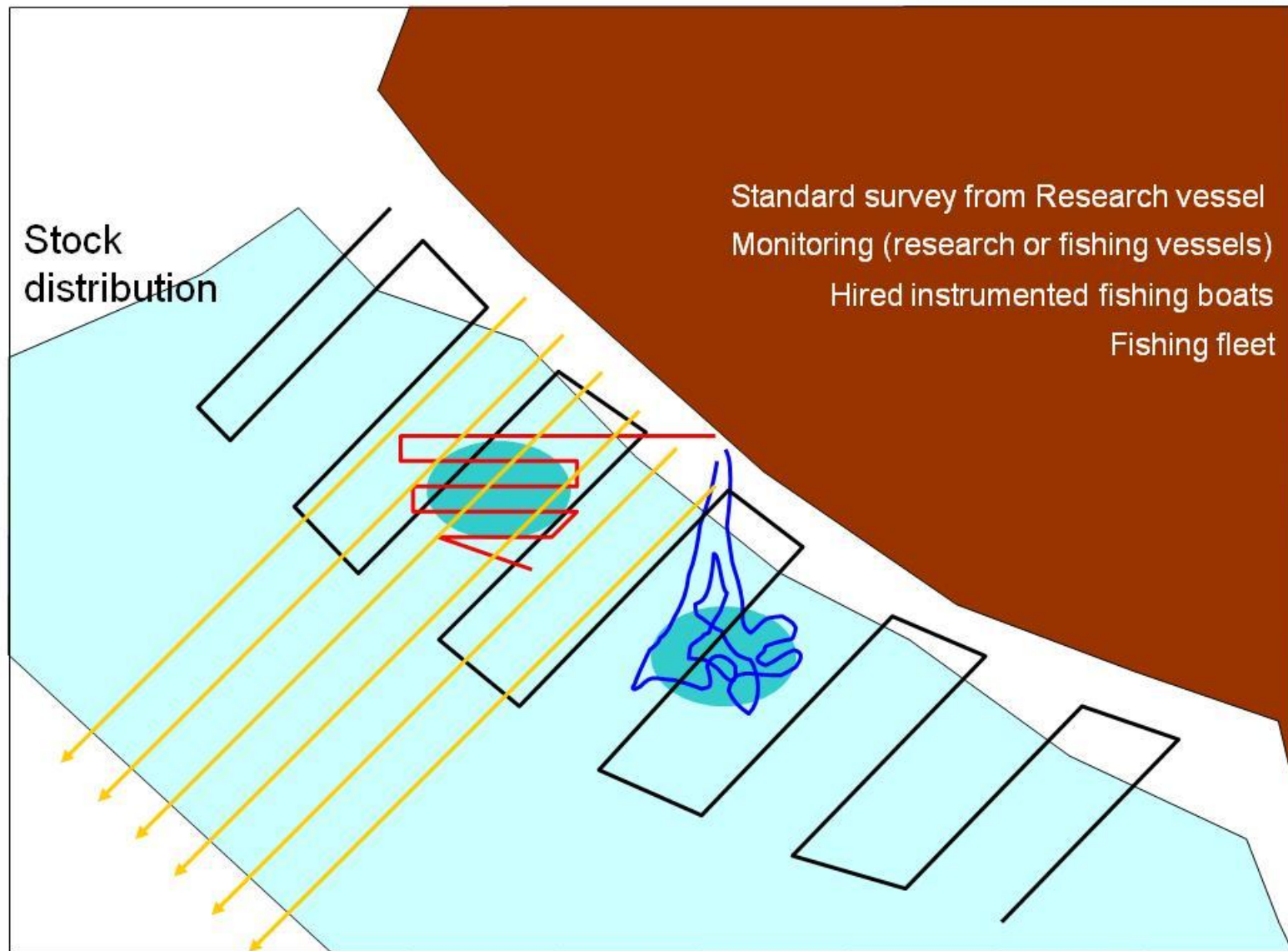
Acoustic data from the fisheries

## Proposals to SPRFMO

*(South Pacific Region Fisheries Management Organization)*



# The different levels of sampling using scientific and fishing vessels



# Criteria for selecting/classifying fishing ships for data collection

## 5 levels

(from 1: equivalent to research vessel, to 5: limited to qualitative observation) classified according to their characteristics in:

Type of equipment (echo sounder)

Calibration feasibility

Noise (and noise measurement)

Capacities in measuring fish biomass and behaviour

Capacities in measuring plankton abundance

Capacities in describing the pelagic habitat (SST, OMZ, thermocline...)

Capacities in recording ecosystem characteristics (seabirds, marine mammals, meteorology...)

| Item        | Systems / Levels                                                                          | Fishing Vessels classification according to their acoustic systems |                                                     |         |         |         |
|-------------|-------------------------------------------------------------------------------------------|--------------------------------------------------------------------|-----------------------------------------------------|---------|---------|---------|
|             |                                                                                           | Level 1                                                            | Level 2                                             | Level 3 | Level 4 | Level 5 |
| Equipment   | Digital echosounders of at least 2 frequencies split beam, scientific sounders or similar |                                                                    |                                                     |         |         |         |
|             | Digital echosounders of 1 frequencies split beam or similar                               |                                                                    | Simrad ES60 + Echoview                              |         |         |         |
|             | Digital echosounders of 1 frequencies single beam                                         |                                                                    |                                                     |         |         |         |
|             | Analogue echosounders of 1 frequencies single beam                                        |                                                                    |                                                     |         |         |         |
|             | All other possible combination                                                            |                                                                    |                                                     |         |         |         |
| Calibration | Calibration using spheres                                                                 |                                                                    | in Echoview                                         |         |         |         |
|             | Calibration using hydrophones                                                             |                                                                    |                                                     |         |         |         |
|             | Noise measurement                                                                         |                                                                    | in Echoview                                         |         |         |         |
|             | Target Strength measurements                                                              |                                                                    | in Echoview                                         |         |         |         |
| Fish        | Accurate fish biomass estimation and classification                                       |                                                                    | In limited areas                                    |         |         |         |
|             | Fish biomass estimation                                                                   |                                                                    |                                                     |         |         |         |
|             | Relative abundance estimations                                                            |                                                                    |                                                     |         |         |         |
|             | Fish typology                                                                             |                                                                    | Visually, in routine                                |         |         |         |
| Zooplankton | Accurate zooplankton abundance estimation and classification                              |                                                                    |                                                     |         |         |         |
|             | Zooplankton abundance estimation                                                          |                                                                    | in Echoview                                         |         |         |         |
|             | Relative zooplankton abundance estimations from visual contact                            |                                                                    |                                                     |         |         |         |
| Habitat     | Depth of oxycline                                                                         |                                                                    |                                                     |         |         |         |
|             | Depth of thermocline                                                                      |                                                                    | in Echoview                                         |         |         |         |
|             | Depth of thermocline from visual contact                                                  |                                                                    |                                                     |         |         |         |
|             | Carbon and CO <sub>2</sub> relative measurements                                          |                                                                    |                                                     |         |         |         |
|             | Prey-predator interactions observations                                                   |                                                                    | in Logbooks                                         |         |         |         |
| Other       | Seabird observations                                                                      |                                                                    | in Logbooks                                         |         |         |         |
|             | Marine mammals observations                                                               |                                                                    | in Logbooks                                         |         |         |         |
|             | Big pelagics and highly migratory fish observations                                       |                                                                    | in Logbooks                                         |         |         |         |
|             | Fishing devices for providing biological sampling                                         |                                                                    | Size structure, collection of biological structures |         |         |         |

## Conclusion: Recommendations to SPRFMO (guideline approved Nov 2009)

- Inventory of common technologies available aboard fishing vessels (**completed**)
- Establish list of criteria for ship selection (**completed**)
- Agreement on an adapted protocol on sampling methods, softwares and instruments (**in course**)
- Evaluation of costs (personal, material, software, time) (**in course**)
- Establish links with ICES through EG on methodologies for fishing ship acoustics (**in course**)

SOUTH PACIFIC REGIONAL FISHERIES MANAGEMENT ORGANIZATION - SPRFMO  
PERUVIAN DELEGATION

SP-08-SWG-JM-11

### Guidelines for Acoustic Data Collection aboard Fishing Vessels operating in the SPRFMO area

DRAFT, October 2009

Submitted by: William Karp (NOAA, USA), Rudy Kloser (CSIRO, Australia), Francois Gerlotto (IRD, France),  
Héctor Peña (IMR, Norway), Mariano Gutiérrez (TASA, Peru).

---

